RISK ASSESSMENT OF CITRONELLA OIL-BASED INSECT REPELLENT LABELS ACCORDING TO WHO

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Abstract

This research aims: 1) to analyze GHS-based hazard of chemical components in a citronella oil-based insect repellent product; and 2) to assess the risk of the product according to the guidelines of WHO. The study selected an aerosol spray insect repellent product with citronella oil after classifying their hazard levels based on GHS (Globally Harmonized System of Classification and Labelling of Chemicals). The research findings were that: 1) hazard data reviewed that citronella and LPG were significant hazardous chemicals. Hazard analysis involved determining NOAEL (no observed adverse effect level) for all substances in the product to characterize their hazard; and 2) the assessment of chemical exposure utilized a scenario of a single spray application in all four corners of a room, totaling 216 milligrams, in a room measuring 17 square meters with 2.5 meters high, typical of residential living spaces. Analysis of data from infant aged 1 year and female adult aged 13-49 years, identified as the highest-risk group, found that LPG had the highest dermal exposure within 24 hours among the target groups. The non-carcinogenic risk characterization involved calculating the HQ (hazard quotient), revealing that citronella oil posed significantly higher risk than 1 through inhalation, with HQ of 13.67 and 4.6 for infant and female adult, respectively. Citronella oil was classified as a type 2 carcinogen, causing cancer in experimental animals. On the other hand, LPG contains 1,3-butadiene as a minor component at approximately 0.0001%, which does not pose a carcinogenic risk to humans.

Keywords: Risk assessment, Insect Repellent product, Citronella Oil

Introduction

The general risk of chemicals refers to the likelihood of adverse health effects on humans or living organisms in the environment resulting from exposure to chemical substances. The level of risk is determined by the inherent hazardous properties of the chemical and the extent of exposure to humans or other living organisms. The consumer exposure risk is evaluated by comparing the estimated exposure levels with reference doses that are expected not to cause harm, even with repeated and long-term exposure, and by analyzing data on the estimated amount of chemical exposure from consumer products.

According to the guidelines of the World Health Organization (WHO), risk assessment consists of four key steps including hazard identification, hazard characterization, exposure assessment, and risk characterization (U.S. Environmental Protection Agency; https:// www.epa.gov/risk/risk-assessment-guidance). These guidelines can be used for risk assessment of various oil such as sesame oil and other volatile oils in many herb products (Hanazawa, K., Fakkham, S., Sangvichien, S., Chinakarn, T., & Arnmanee, P., 2022).

Insect repellent products contain citronella oil as an active ingredient. Citronella oil is an essential oil extracted from citronella grass, include important active components such as camphor, cineol, eugenol, citral, linalool, citronellal, and geraniol, which are effective in repelling insects (Subagiyo, et al., 2024). These components protect against mosquitoes that transmit malaria, dengue fever, and lymphatic filariasis.

However, research by Soontornchai (2018) classified the hazards of various insect repellent products containing citronella oil and found that prolonged or repeated exposure may cause harm to the respiratory system, skin irritation, and severe eye damage. Therefore, risk assessment of household insect repellent products containing citronella oil is essential, especially for aerosol spray formulations commonly used in homes, which often contain high concentrations of citronella oil and may pose risks to residents.

Research Objectives

1. To analyze the hazards of chemical substances used in an insect repellent product containing citronella oil.
2. To assess the risk of the insect repellent product containing citronella oil as an active ingredient based on WHO guidelines.

Scope of Research

An insect repellent product containing citronella oil as the active ingredient based on Soontornchai (2018), by classifying its hazards according to GHS and then risk assessment of the product according to the guidelines of WHO.

Research Methodology

1. Select an insect repellent product with citronella oil as the active ingredient in accordance with GHS for chemical classification. The study focuses on evaluating the aerosol spray insect repellent product with citronella oil that are used domestically (not for automatic dispensers) (https://www. epa.gov/ pesticide-science-and-assessing-pesticide-risks/standard-operating-procedures-residential-pesticide) based on the formulation found in the study by Soontornchai (2018). The detailed formula of the insect repellent product containing citronella oil is shown in Table 1.

Table 1 Formulation of Citronella Oil-Based Insect Repellent Product

Component	CAS No.	Function in Product	%W/W	%W/W (Actual)
Citronella oil	89998-15-2	Active ingredient	12.00	12.00
Propylene Glycol	57-55-6	Solvent	0.50	0.50
Lavender	8000-28-0	Fragrance additive	1.00	1.00
Ethyl alcohol 96.5%	64-17-5	Solvent	24.75	23.95
LPG	68476-85-7	Propellant	61.75	61.75
Water	—	—	—	0.80
Total			**100.00**	**100.00**

2. Search for hazard information of the chemical components used in the product from chemical-related databases and organizations.
3. Analyze the hazards of the chemicals in the product sample, focusing on physical and chemical hazards, health hazards, and environmental hazards. This study uses hazard classification data from Soontornchai (2018) as follows:

Table 2 Hazard Classification of Insect Repellent Products Containing Citronella Oil According to GHS

Hazard Category	Citronella oil	Propylene glycol	Lavender	Ethanol	LPG	Water	Product
% in Formula	12	0.50	1.00	23.95	61.75	0.8	100
1. Physical Hazards	Flammable liquid 3			Flammable liquid 3	Flammable liquid 1		1
2. Acute Toxicity							
2.1. Oral	NC	NC	5	5	NP		NC
2.2 Dermal	5	NC	5	NC	NP		NC
2.3 Inhalation	NP	5	NP	NC	NC		NC
3. Skin Corrosion and Irritation	2	3	2	2	2		2
Hazard Category	Citronella oil	Propylene glycol	Lavender	Ethanol	LPG	Water	Product
% in Formula	12	0.50	1.00	23.95	61.75	0.8	100
4. Serious Eye Damage and Eye Irritation	1	2A	2A	2A	2B		1
5. Respiratory or Skin Sensitization							
5.1 Respiratory Sensitization	NP	NP	NP	NC	NP		NP
5.2 Skin Sensitization	1	NP	1	NC	1		1
6. Germ Cell Mutagenicity	2	NP	NP	NC	1B		1B
7.Carcinogenicity	2	NP	NP	NC	1B		1B
8. Reproductive Toxicity	NP	NP	NP	NP	1A		1A
9. Specific Target Organ Toxicity – Single Exposure	1 Respiratory system	3	3	NP	1		1 Respiratory system
10. Specific Target Organ Toxicity – Repeated Exposure	1 Respiratory system	1 Digestive system, Nervous system	1 Skin	1 Nervous system, Liver	2		1 Respiratory system, Nervous system, Liver
11. Aspiration Hazard	1	NP	1	NP	NP		1
12. Acute Aquatic Toxicity	2	NC	3	NC	NC		3
13. Chronic Aquatic Toxicity	2	NC	3	NC	NC		3
14. Hazard to the Ozone Layer	NP	NP	NP	NP	NC		NP

Source: Soontornchai, S. (2018).

(NP) Not possible to classify = Insufficient data

(NC) Not classified = No hazard or considered safe according to GHS

Research Results

Risk assessment of insect repellent products containing citronella oil according to WHO Guidelines comprises four key steps (https://www.epa.gov/risk/risk-assessment-guidance) summarized as follows:

1. **Hazard Identification:**

Citronella oil and LPG are the primary hazardous components of the product. Citronella oil is a physically hazardous, flammable liquid. Its major health hazards include eye damage, skin irritation, and respiratory toxicity. Chronic exposure may lead to germ cell mutagenicity, carcinogenicity, and reproductive toxicity. It is also acutely and chronically toxic to aquatic environments.

LPG has similar hazards to citronella oil, with potential mutagenicity, carcinogenicity, and reproductive toxicity observed in both animals and humans. However, it is not considered hazardous to aquatic environments.

2. **Hazard Characterization:**

This step involves toxicological studies in animals, with extrapolation to humans using a default uncertainty factor of 100 based on NOAEL values:

- **Inhalation Exposure:**
  - Citronella oil: 0.003 mg/kg
  - Ethyl alcohol 96.5%: 160 mg/kg
  - LPG: 514.286 mg/kg/day
- **Dermal Exposure:** No reference values provided.
- **Oral Exposure:**
  - Citronella oil: 0.5 mg/kg/day
  - Propylene glycol: 0.8 mg/kg/day
  - Lavender: 5 mg/kg/day
  - Ethyl alcohol 96.5%: 36 mg/kg/day

3. **Exposure Assessment:**

This step evaluates exposure through ingestion, inhalation, and dermal absorption for all chemical substances in the product. One spray is considered to be 216 mg (54 mg per corner × 4 corners), in a room of 17 m² with 2.5 m. high. This reflects a typical testing room size as used by the Department of Medical Sciences, Thailand.

LPG showed the highest dermal exposure in both one-year-old children and women aged 13–49, the most vulnerable groups.

4. **Risk Characterization:**

There are two types of risk characterization based on chemical response in the body:

- **Non-carcinogenic Risk:** Assessed by HQ
  - Citronella oil showed the highest HQ via inhalation:
    - 13.67 for one-year-old children
    - 4.6 for adult women (13–49 years old)
- **Carcinogenic Risk:** Evaluated using CPF (Cancer Potency Factor) (CPF × exposure dose).
  - Citronella oil is classified as a Category 2 carcinogen (animal evidence only) (ECHA), but no CPF value was found.
  - LPG contains 1,3-butadiene (a carcinogen in rodents and humans) in a very low concentration (~0.0001%), suggesting a minimal cancer risk.

Conclusion and Discussion

Citronella Oil is Corrosive and irritating to the skin (Category 2), causes serious eye damage (Category 1), and may cause skin sensitization (Category 1). It should be handled with caution to avoid skin and eye contact. Mutagenicity and carcinogenicity are based on animal data only. No reproductive toxicity data available.

LPG has similar irritation properties to citronella oil. Contains known human carcinogens (1B) and reproductive toxins (1A), but actual inhalation exposure levels are much lower than the reference value (1,800 mg/m³ or 514.286 mg/kg/day). HQ values for dermal and oral exposure could not be calculated due to missing reference data. Avoid skin and eye contact and ingestion.

LPG and citronella oil are classified as carcinogens (IARC). LPG is Category 1B carcinogen due to 1,3-butadiene content (0.0001%) Citronella oil is Category 2 carcinogen (animal studies only).

LPG is commonly used as a vehicle fuel and aerosol propellant in household sprays, and safe usage guidelines are in place.

Although the product forms an aerosol and disperses quickly, direct contact with skin or eyes is unlikely. Based on existing data, the dermal exposure level is minimal (assuming 50% body surface contact and 10% dermal absorption rate). Oral exposure is rare, except possibly from young children taking objects into their mouths.

Due to the high 24-hour inhalation exposure level of citronella oil and resulting high HQ values, especially for children and adult women, it may be necessary to reduce the citronella oil content. This is in line with recommendations by Soontornchai (2018), who suggested: ≤1% citronella oil to avoid long-term inhalation risks and ≤3% to prevent serious eye damage.

Consideration must also be given to the interaction with other ingredients that may increase toxicity and the effectiveness of the repellent at lower citronella concentrations.

Recommendations:

1. **Based on Current Research:**
   - Avoid inhalation and direct contact with skin and eyes.
   - Citronella oil may cause severe eye damage and irritation, possibly affecting the nervous system and liver upon repeated exposure.
   - In case of eye exposure, rinse with clean water and discontinue use.
   - Avoid use in high temperature or near static electricity due to flammability risks.
2. **For Future Research:**
   - Test formulations with ≤1% citronella oil to determine if insect repellent efficacy is maintained with reduced HQ values.
   - Identify alternative insect-repelling ingredients with less impact on the respiratory system.

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